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Technical Memorandum

Nitrate Occurrence in the Monk Hill Subarea National Aeronautics and Space Administration, Jet Propulsion Laboratory, Pasadena, California

Revised Final November 7, 2005

This technical memorandum provides an evaluation of nitrate concentrations in production wells and monitoring wells located in the Monk Hill Subarea. This memorandum was prepared to support the experiment conducted by the City of Pasadena at the Windsor Well between July 12 and July 14, 2005. The objective of the experiment was to evaluate the nitrate levels in the Windsor Well during a 26 hours pump test.

The Windsor Well was taken out of service in January 2002, but continued to be sampled for water quality testing and monitoring. Because nitrate concentrations obtained from the Windsor Well during this water quality testing and monitoring period were higher than concentrations obtained while the Windsor Well was operating, one of the goals for the Windsor Well experiment was to verify the nitrate levels before, during, and after a longer runtime than was typical during water quality testing and monitoring periods.

Results of the Windsor Well experiment showed that nitrate levels decreased with increasing runtime. For instance, nitrate concentrations decreased from 49 µg/L to 40 µg/L after a runtime of 28 hours and following a 24-hour shutdown period the levels decreased at a faster rate from 46 µg/L to 40 µg/L after only two hours of runtime.

The evaluation of nitrate concentrations in production wells and monitoring wells located in the Monk Hill Subarea is provided here to further explain the increasing nitrate concentrations in the production wells that are no longer in service.

The nitrate evaluation presented in this technical memorandum was conducted as part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program at the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL).

City of Pasadena Monk Hill Wells

Figure 1 shows the nitrate concentrations over time in samples collected from the Arroyo Well, Well 52, Ventura Well, and Windsor Well. Nitrate data for the Arroyo Well were limited, consisting of only seven sampling events. Nitrate concentrations in the Arroyo Well were relatively low, remaining at or below 25 mg/L through February 1997, at which time operation ceased.

During operation of Well 52, concentrations of nitrate tended to fluctuate monthly but remained below the maximum contaminant level (MCL) of 45 mg/L. Operation of Well 52 was stopped in early 2002. As shown on Figure 1, an increasing concentration trend began April 2002 and continued through October 2002. Nitrate concentrations first exceeded the MCL in July 2002 and continued to exceed through October 2002. It appears that nitrate concentrations increased after operation of the well stopped.

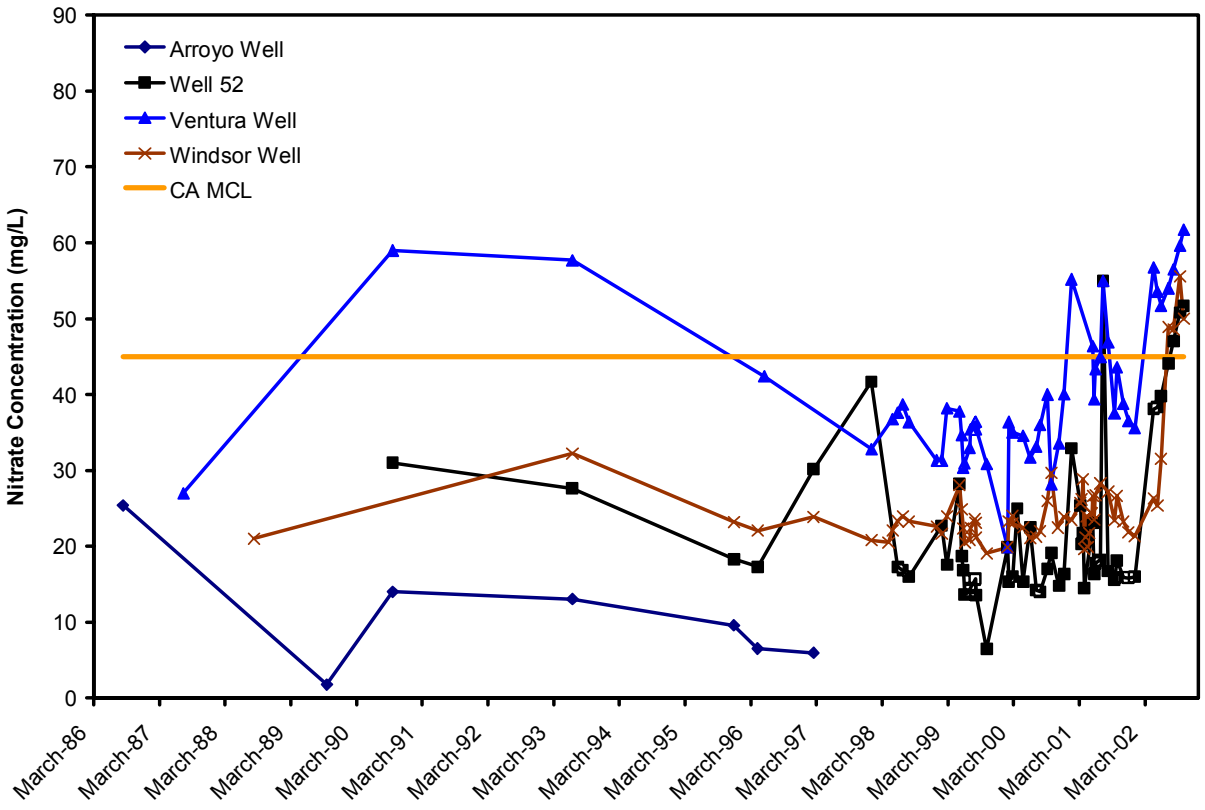

Figure 1. Nitrate Concentrations in the City of Pasadena Monk Hill Wells

For the Ventura Well, concentrations of nitrate were above the MCL in the early 1990s, but decreased to concentrations below the MCL in May 1996 and continued to stay below the MCL up until January 2001. A slight increasing trend is noticeable in 2001 compared to previous years. Throughout 2001, nitrate concentrations tended to fluctuate and at times exceeded the MCL. Ventura Well was shutdown in January 2002. Beginning in April 2002, an increasing trend is evident in which nitrate concentrations are consistently detected above the MCL. Again, it appears that nitrate concentrations increased after operation of the well stopped.

For the Windsor Well, nitrate concentrations were below the MCL, ranging between 20 and 30 mg/L up until June 2002. The Windsor Well was shutdown in January 2002. As indicated on Figure 1 and similar to Well 52 and Ventura Well, an increasing trend in nitrate levels was observed after the well was shut down.

Although Ventura, Windsor, and Well 52 were taken out of service in the middle of January 2002, city staff continued to run the wells once a month for 15 to 30 minutes to collect samples strictly for water quality testing and monitoring. Thus, samples collected after January 2002 were the result of the continued water quality testing and monitoring of these wells.

Additional observations for Figure 1:

- The Ventura Well has had the highest nitrate concentrations, followed by Windsor Well;
- Arroyo Well and Well 52 have had the lowest nitrate concentrations;

- An increasing trend for Ventura, Windsor, and Well 52 is observed for the 2002 data (concentrations in 2002 are much higher than what was being monitored while these wells were operating);
- It appears that samples collected from non-operating wells may be associated with elevated nitrate concentrations.

Other Monk Hill Wells

Figure 2 presents the nitrate concentrations over time in the several other Monk Hill wells located downgradient of JPL. Las Flores Water Company (LFWC) Well No. 2 is the only well with nitrate concentrations exceeding the MCL. Nitrate concentrations in the LFWC#2 have ranged between 34 mg/L and 60 mg/L.

For Rubio Cañon Land and Water Association (RCL&WA) Well No. 4, nitrate concentrations in the early 1990s exceeded the MCL, but since then concentrations have remained below the MCL except for one sampling event in July 1995. Since 1997, nitrate concentrations have ranged between 15 mg/L and 40 mg/L. From July 1995 to January 2003, a slight deceasing trend in nitrate concentrations is evident.

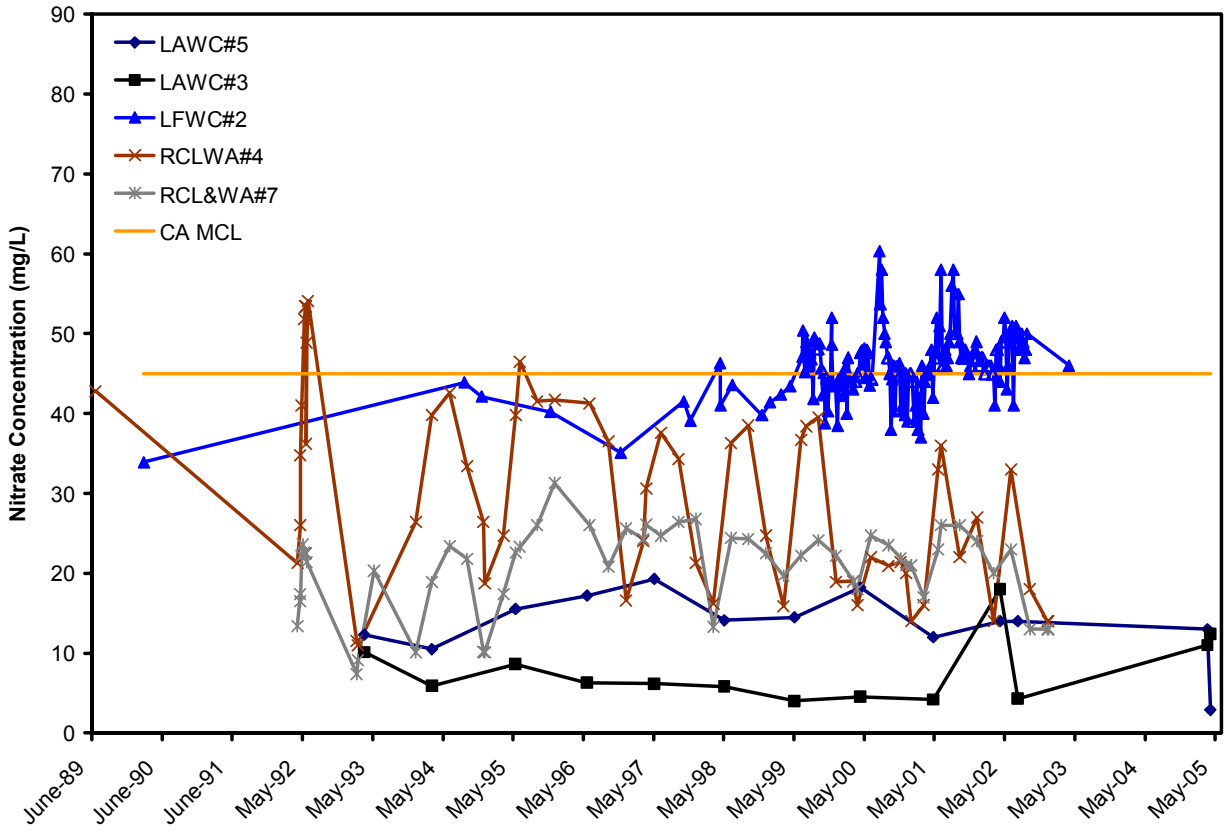

Figure 2. Nitrate Concentrations in the Other Monk Hill Wells

For RCL&WA#7, nitrate concentrations have never exceeded the MCL. Concentrations have ranged from 7 mg/L to 31 mg/L.

For Lincoln Avenue Water Company (LAWC) Wells 3 and 5, nitrate concentrations have never exceeded the MCL. Maximum nitrate concentrations have been less than 20 mg/L.

Additional observations for Figure 2:

- There is no evidence of an increasing trend in the other Monk Hill Subarea wells beginning in 2002.
- LFWC#2 contains higher nitrate concentrations than the LAWC and RCLWA wells;

Valley Water Company

Nitrate concentrations in the Valley Water Company (VWC) wells (Figure 3) are generally higher than those observed in the other Monk Hill Subarea production wells. The MCL for nitrate has been exceeded in all four VWC wells. The consistent pattern present in the nitrate levels (lower nitrate concentrations present during the May/June months, and the higher nitrate concentrations present during the July/August/September months) is likely caused by the effects of injection of imported water at these wells. Lower nitrate levels are observed during periods of imported water injection and higher nitrate detections are observed when injection is not occurring. Nitrate concentrations in samples collected from the VWC wells have been as high as 84 mg/L. Elevated nitrate levels are believed to be associated with unsewered areas in La Cañada.

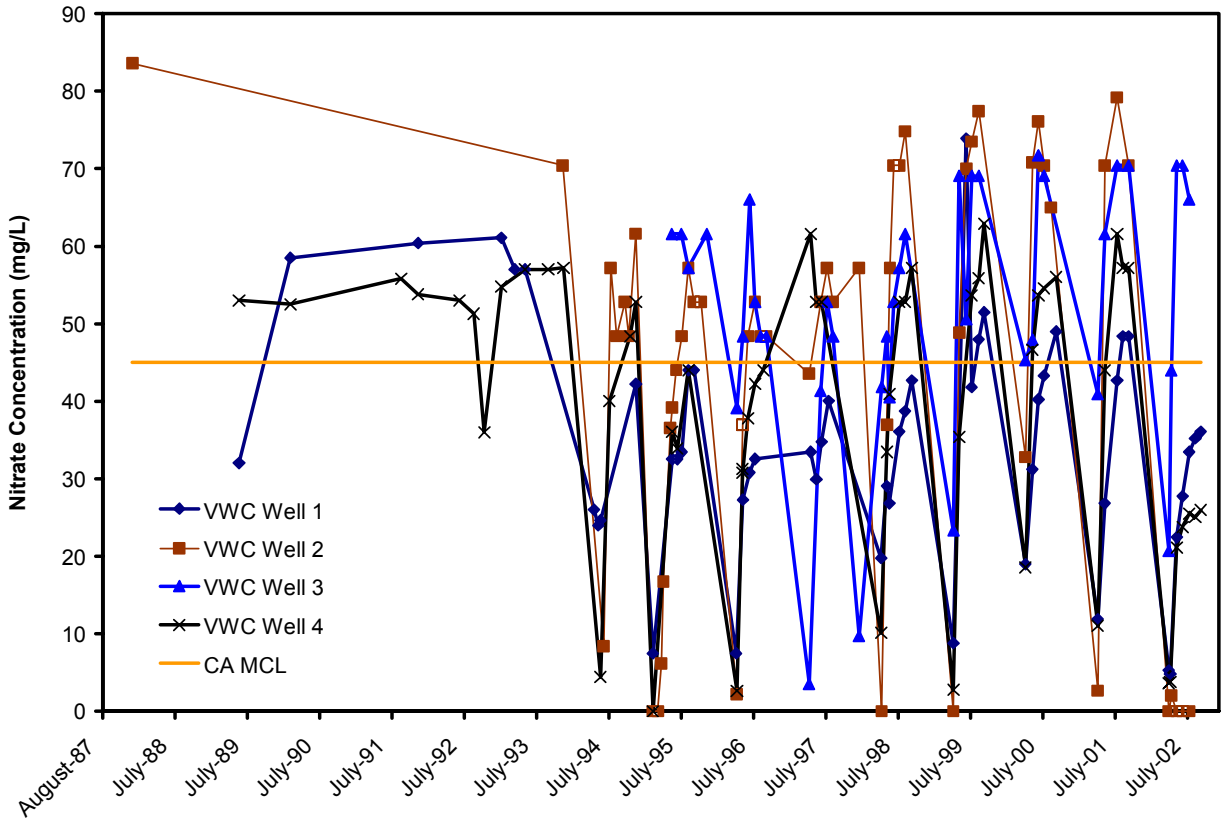

Figure 3. Nitrate Concentrations in the Valley Water Company Wells

JPL Monitoring Wells

Nitrate concentrations in samples collected from six multi-port JPL monitoring wells (MW-14, MW-17, MW-18, MW-19, MW-20, and MW-21) are shown on Figures 4 through 9. Results from all sampling ports are provided on these figures. For this technical memorandum, nitrate concentration data from the JPL wells was converted from nitrate as nitrogen (NO_3–N) to nitrate as nitrate (NO_3-NO_3). This conversion was done so that these data could be compared to the production well data which is reported as NO_3-NO_3. For each monitoring well, the shallower screened interval contains the higher nitrate concentration, which is consistent with a release occurring near the ground surface (e.g., unsewered areas, fertilizer application). Observations associated with each of the monitoring wells are provided below.

MW-14:

- This well is located nearest to the VWC Wells.
- Nitrate concentrations have consistently been detected between 40 mg/L and 90 mg/L since late 1998.
- Out of the six JPL wells presented here, MW-14 (screens 1 – 4) maintains the highest nitrate concentrations consistently over time.
- There is no evidence of an increasing trend in nitrate concentrations in MW-14 beginning in 2002.

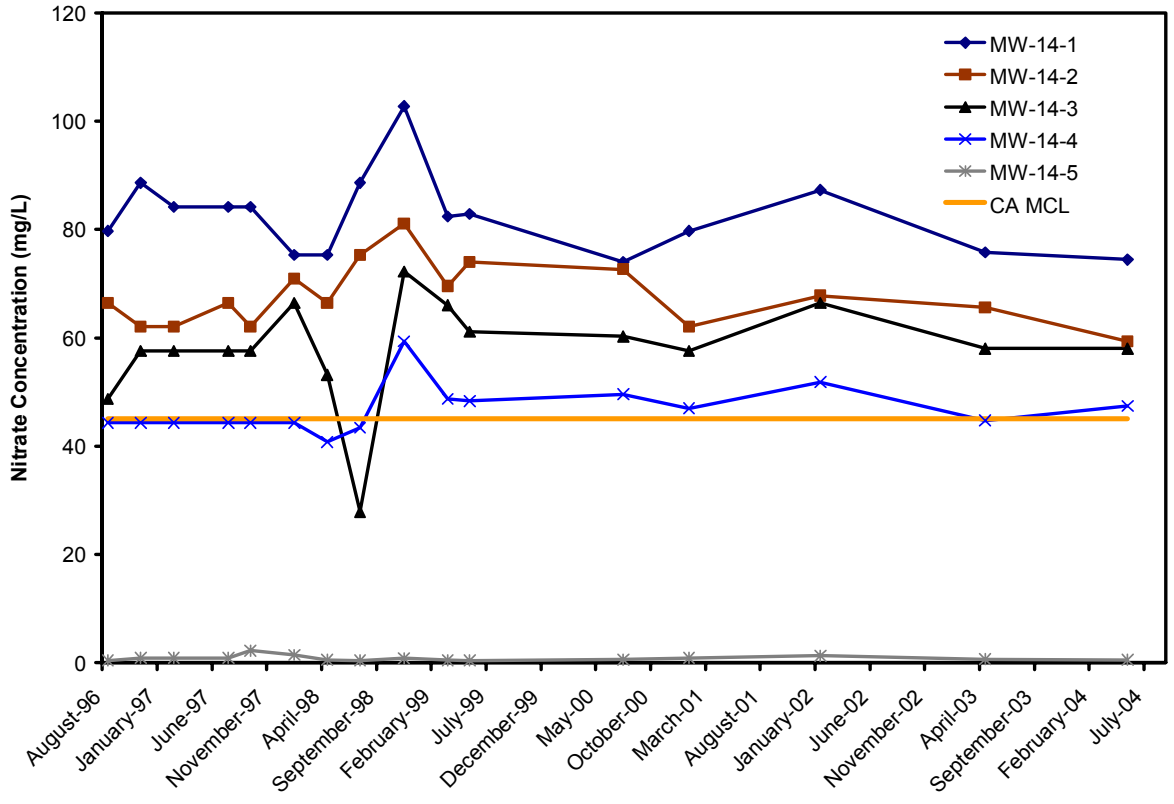

Figure 4. Nitrate Concentrations in MW-14

MW-17:

- This well is located approximately 500 feet west of the LAWC well #3.
- Nitrate concentrations have been less than 10 mg/L in all screened intervals except for screen 2 in May 2004;
- Nitrate concentrations in screen 2 have noticeably increased since May 2003;
- Nitrate concentrations in screens 4 and 5 have been decreasing.

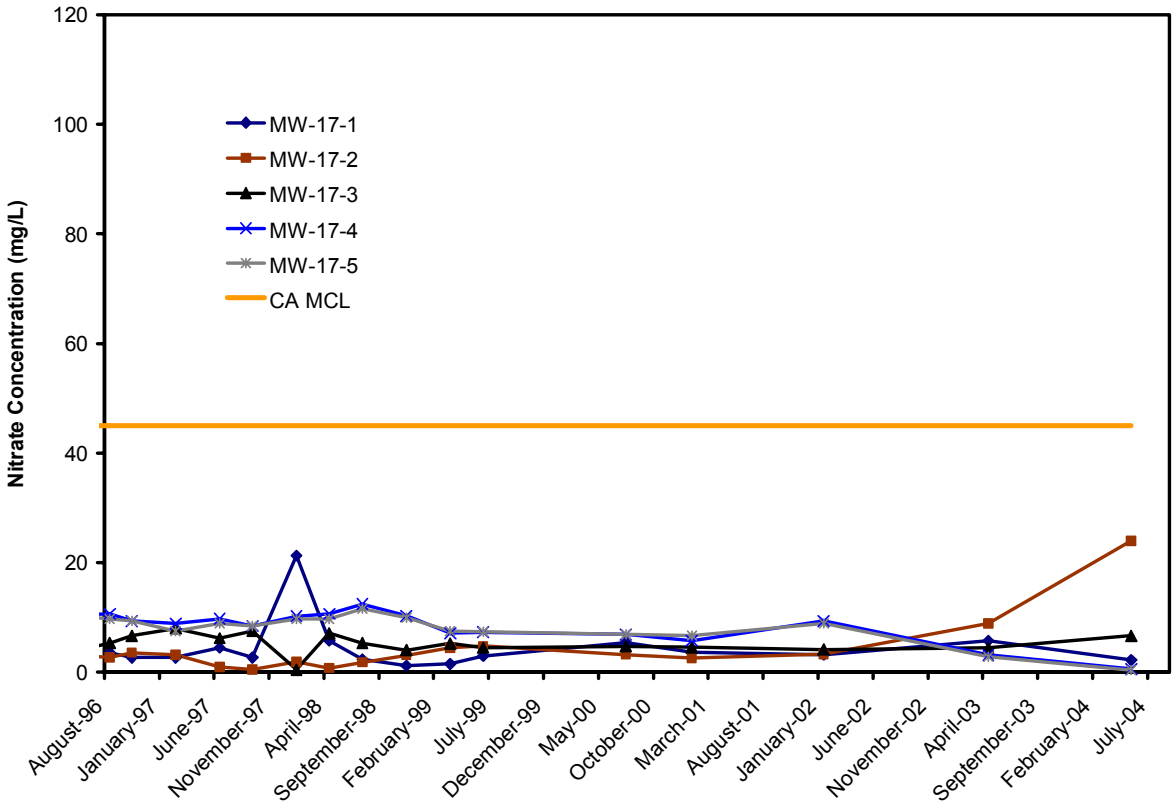

Figure 5. Nitrate Concentrations in MW-17

MW-18:

- This well is located a considerable distance north of the Monk Hill wells and is closest to the Arroyo Well.
- Nitrate concentrations have been less than 10 mg/L since mid 1998;
- Nitrate concentrations in screen 1 and 3 indicate an increasing trend since 1999 (although concentrations remain below 10 mg/L).
- There is no evidence of an increasing trend in nitrate concentrations in MW-18 beginning in 2002.

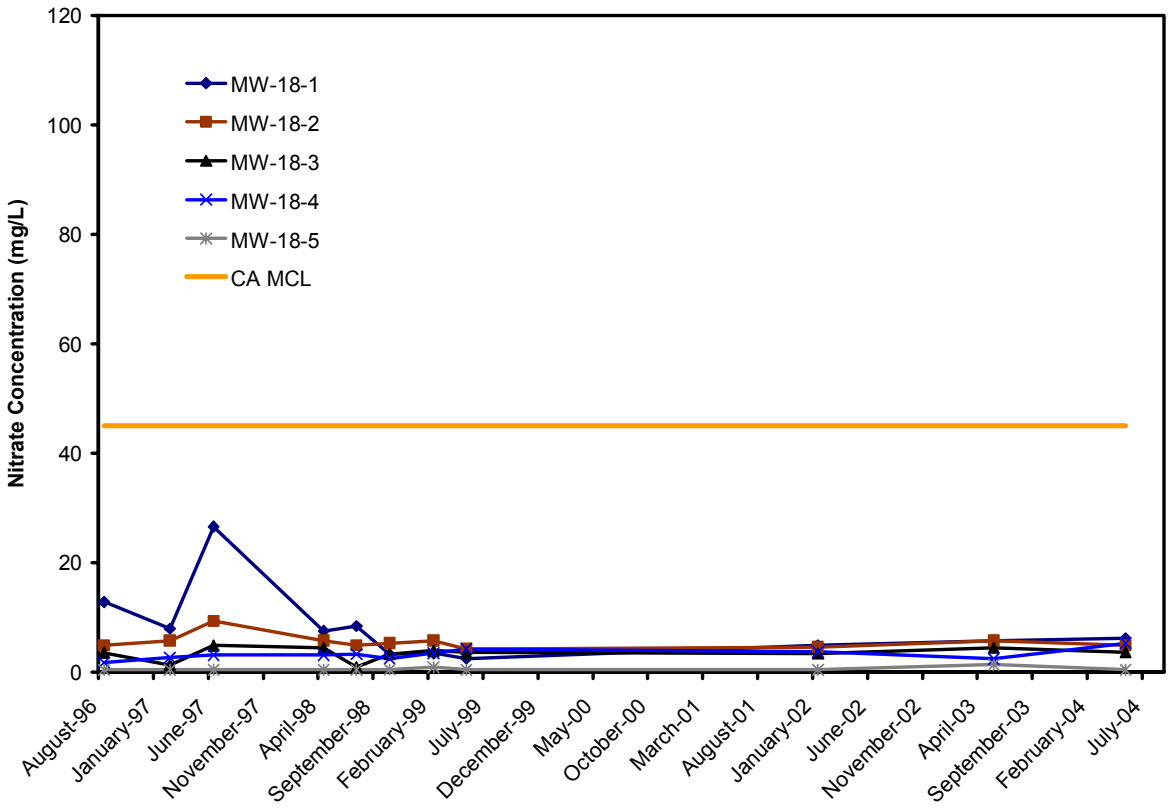

Figure 6. Nitrate Concentrations in MW-18

MW-19:

- This well is located within the City of Pasadena Windsor Reservoir property approximately 500 feet south of the Windsor Well.
- Nitrate concentrations were consistently detected below 10 mg/L for Screen 1, until April 2004.
- Nitrate in screen 2 was consistently detected between 10 mg/L and 40 mg/L until April 2003 when it was detected at 55.4 mg/L;
- It appears that after January 2002, nitrate concentrations in Screen 2 noticeably increased, while concentrations in Screen 5 decreased;
- Nitrate in Screen 4 began increasing after January 2002;
- Nitrate concentrations in Screen 3 are consistently between 40 and 50 mg/l.

MW-20:

- MW-20 is located approximately midway between LAWC#5 and RCL&WA#4.
- Nitrate concentrations in Screen 1 tended to fluctuate, ranging between 37 mg/L and 84 mg/L, but noticeably decreased to 10 mg/L in early 2003;
- Nitrate concentrations in Screens 2 through 5 have been fairly consistent over time and always less than 20 mg/L.
- There is a noticable decreasing trend in nitrate concentrations in MW-20 (Screen 1) beginning in 2002.

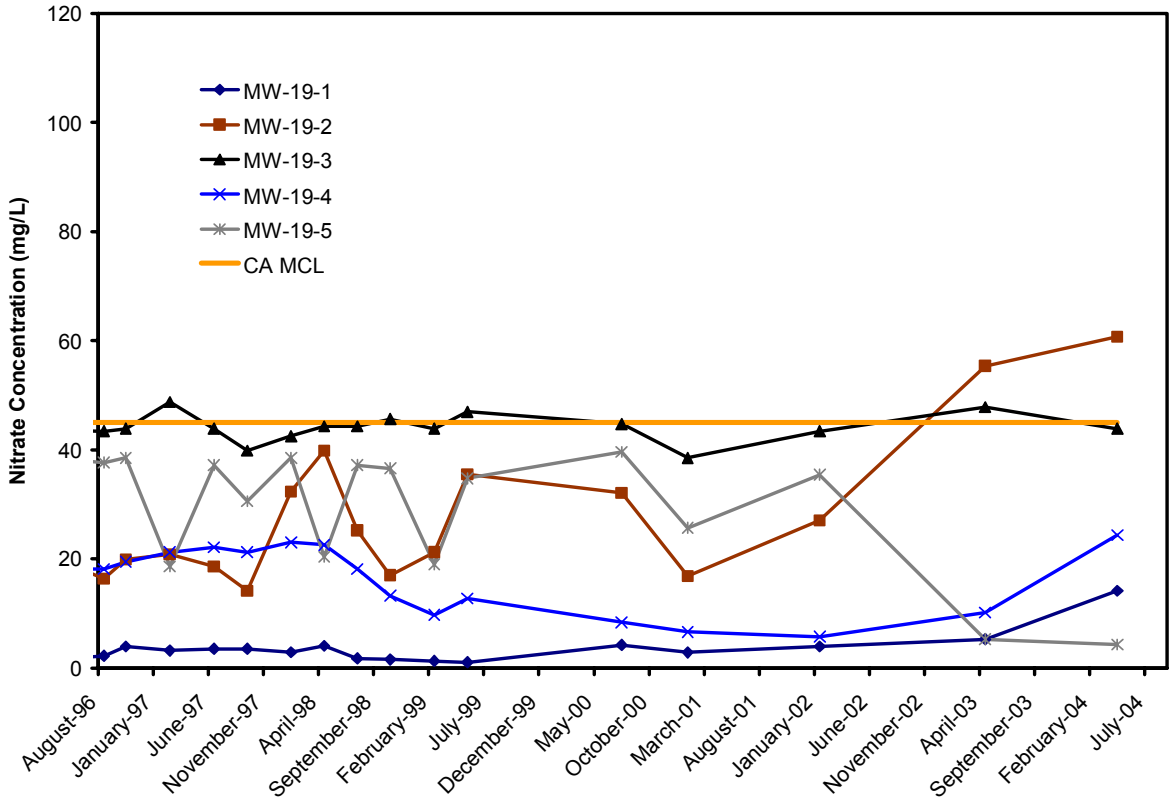

Figure 7. Nitrate Concentrations in MW-19

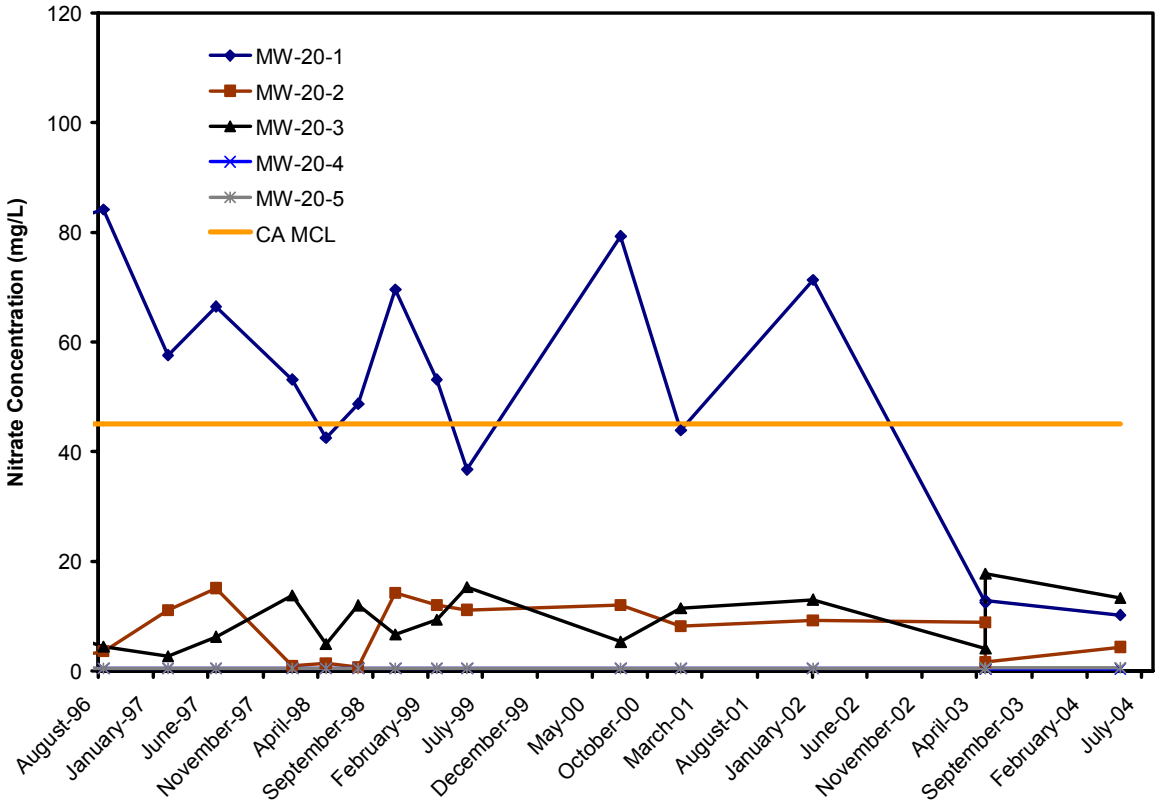

Figure 8. Nitrate Concentrations in MW-20

MW-21:

- Well MW-21 is located south of the JPL facility approximately midway between the VWC wells and the Windsor Well.
- Nitrate concentrations in Screen 1 have been erratic, ranging from non-detect to 76 mg/L, with the majority of concentrations between 50 mg/L and 77 mg/L.
- Nitrate concentrations in Screens 2 through 5 have been fairly consistent over time, ranging between 17.2 mg/L and 52 mg/L.
- There is no evidence of an increasing trend in nitrate concentrations in MW-21 beginning in 2002.

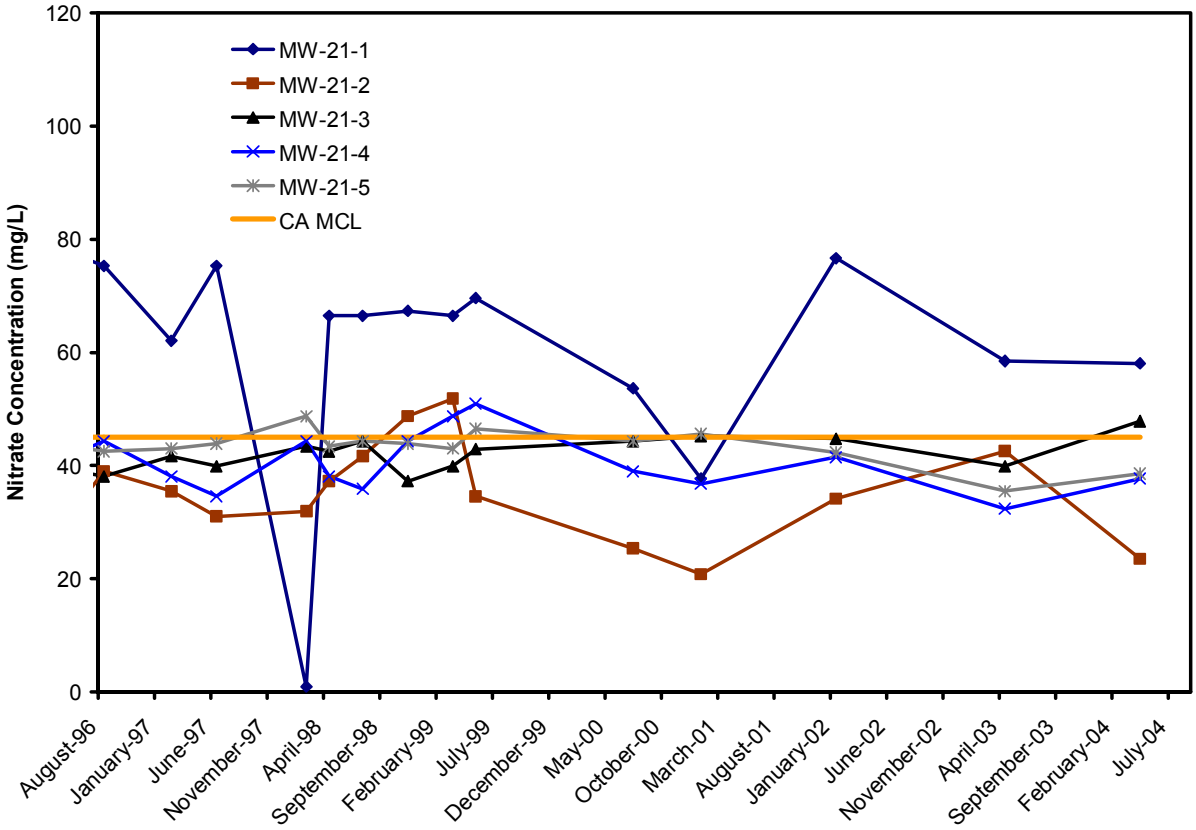

Figure 9. Nitrate Concentrations in MW-21

Overall Summary of Nitrate Occurrence in the Monk Hill Subarea

- Nitrate concentrations in the City of Pasadena wells were historically similar to nitrate concentrations in the other Monk Hill Wells while these wells were operating;
- Nitrate concentrations in the City of Pasadena wells increased after the wells were shut down (2002 time frame);
- Nitrate concentrations in the other Monk Hill wells remained fairly consistent after the City of Pasadena Wells were shut down (after 2002);
- Nitrate concentrations in the Valley Water Company wells have been consistent over time, slightly increasing in 1999, but retaining a pattern similar to previous years;
- Higher nitrate concentrations are observed in the shallower screened intervals of the JPL wells;

- Increasing nitrate concentrations have been observed in MW-19 Screens 1, 2, and 4 and MW-17 Screen 2;
- Decreasing nitrate concentrations have been observed in MW-19 Screen 5, MW-17 Screens 1 and 5, and MW-20 Screen 1.

Discussion

Nitrate concentrations in other Monk Hill wells located upgradient (i.e., VWC wells) and downgradient of the Pasadena Monk Hill wells have remained relatively consistent before and since the Pasadena Monk Hill wells were taken offline in January 2002. Considering these data, an increasing nitrate trend in the basin does not seem possible to explain nitrate increases in Pasadena's Monk Hill wells after 2002.

However, one possible explanation is the association of nitrate concentrations and groundwater flow pathways. According to the information provided in the OU-1/OU-3 Remedial Investigation (RI) report (Foster Wheeler, 1999) the direction of groundwater flow is dynamic. In order to evaluate these dynamics, an evaluation using a variety of data (e.g., water levels, hydraulic head measurements, monthly precipitation data, extraction data, and basin recharge amounts) collected from within the Monk Hill Subarea was conducted during the RI to ascertain groundwater flow conditions and effects outside influences have on the aquifer. For more detailed information regarding the groundwater flow pathway evaluation, please refer to Section 3.4.3 of the RI (http://jplwater.nasa.gov/NMOWeb/AdminRecord/docs/NAS71001.htm).

The stratigraphy of the area was evaluated and four hydrogeologic layers of the aquifer were identified based on depth, lithology, and the way screened intervals in the JPL multi-port wells responded to pumping of nearby municipal production wells. The four aquifer layers in the study area include the upper and lower sections of the Older Fanglomerate Series (aquifer Layers 1 and 2, respectively), the Pacoima Formation (aquifer Layer 3) and the Saugus Formation (aquifer Layer 4). It was determined that Layers 2 and 3 are most appropriate for evaluation of the Pasadena Monk Hill wells. A summary of the RI findings for Layers 2 and 3 are provided below.

To illustrate various flow paths in Aquifer Layer 2, contour maps of hydraulic-head elevations were prepared for a period when no municipal production wells were pumping (Figure 10), a period when only the Lincoln Avenue Water Company was pumping (Figure 11), a period when only the Pasadena wells were pumping (Figure 12), and a period when all nearby municipal production wells were pumping (Figure 13).

As illustrated on Figure 10, groundwater flow in Aquifer Layer 2 is to the southeast, towards MW-20 when the nearby municipal production wells are not pumping. When the LAWC #3 is turned on (Figure 11), little impact to Layer 2 is observed; thus the groundwater flow is still to the southeast towards MW-20. When the Pasadena Monk Hill wells are pumping (Figure 12), significant impacts, as far downgradient as MW-20, are observed on the potentiometric surface in aquifer Layer 2. When all nearby production wells are pumping (Figure 13), the impacts to Layer 2 near the Pasadena Monk Hill Wells are not significantly impacted. The effects of municipal well pumping on groundwater flow in Layer 3 are similar to Layer 2 and are presented in Figures 14 through 17.

As illustrated on Figure 14, groundwater flow in Aquifer Layer 3 is to the southeast, towards well MW-20 when the nearby municipal production wells are not pumping. When the LAWC #3 is turned on (Figure 15), little impact to Layer 3 is observed; thus the groundwater flow is still to the southeast towards MW-20. Similar to Aquifer Layer 2, pumping of the Pasadena Monk Hill wells has a very significant impact on the potentiometric surface in aquifer Layer 3. As shown on Figure 16, when only the Pasadena wells are pumping, the cone of depression in the potentiometric surface extends a great distance. The cone of depression developed in Layer 3 during pumping of the Pasadena wells is much deeper, and broader than is developed in the other layers. When pumping, the La Cañada Irrigation District, VWC, LFWC, and RCL&WA wells do not impact the potentiometric surface in Layer 3 beneath JPL (Figure 17).

Based on the historical nitrate concentration data for the Pasadena Monk Hill wells (Figure 1), nitrate concentrations in Well 52, Ventura Well, and Windsor Well were relatively consistent, and in general, were below the MCL when all three wells were operating. The reason for this consistent nature may be attributed to the rather large areas of influence these wells have while pumping (Figures 12 and 16). As observed on Figures 12 and 16, the cone of depression in the potentiometric surface extends a relatively large distance. Thus, groundwater from the areas of higher nitrate concentrations (i.e., VWC wells and the La Cañada Irrigation District) are combined with the groundwater from areas of lower nitrate concentrations (i.e., from the north and northeast portions of the basin). After the wells were shut down in 2002, nitrate concentrations increased (Figure 1) because the natural groundwater flow to the southeast was reestablished. As evidenced on Figures 10 and 14, when the Pasadena wells are not pumping, groundwater flow is to the southeast; thus groundwater from the areas of higher nitrate concentrations (i.e., VWC wells and the La Cañada Irrigation District) naturally flows towards the Pasadena wells. Nitrate concentrations and groundwater flow changes also are evident for MW-19. When the Pasadena wells were operating, nitrate concentrations in MW-19 were consistent and below the MCL (Figure 7). However, nitrate concentrations in Layers 2 and 3 of MW-19 started increasing after the Pasadena wells were shut down. The area of influence the Pasadena wells, Windsor Well in particular, has on MW-19 is significant (Figures 12 and 16). When this area of influence was removed (i.e., the Pasadena wells shut down), the natural groundwater flow to the southeast was reestablished, thereby resulting in higher nitrate concentrations in MW-19.

Based on the results of the groundwater flow evaluation, it is anticipated that nitrate concentrations comparable to historical concentrations (before 2002) will be observed once the production wells have been in operation for some period of time.

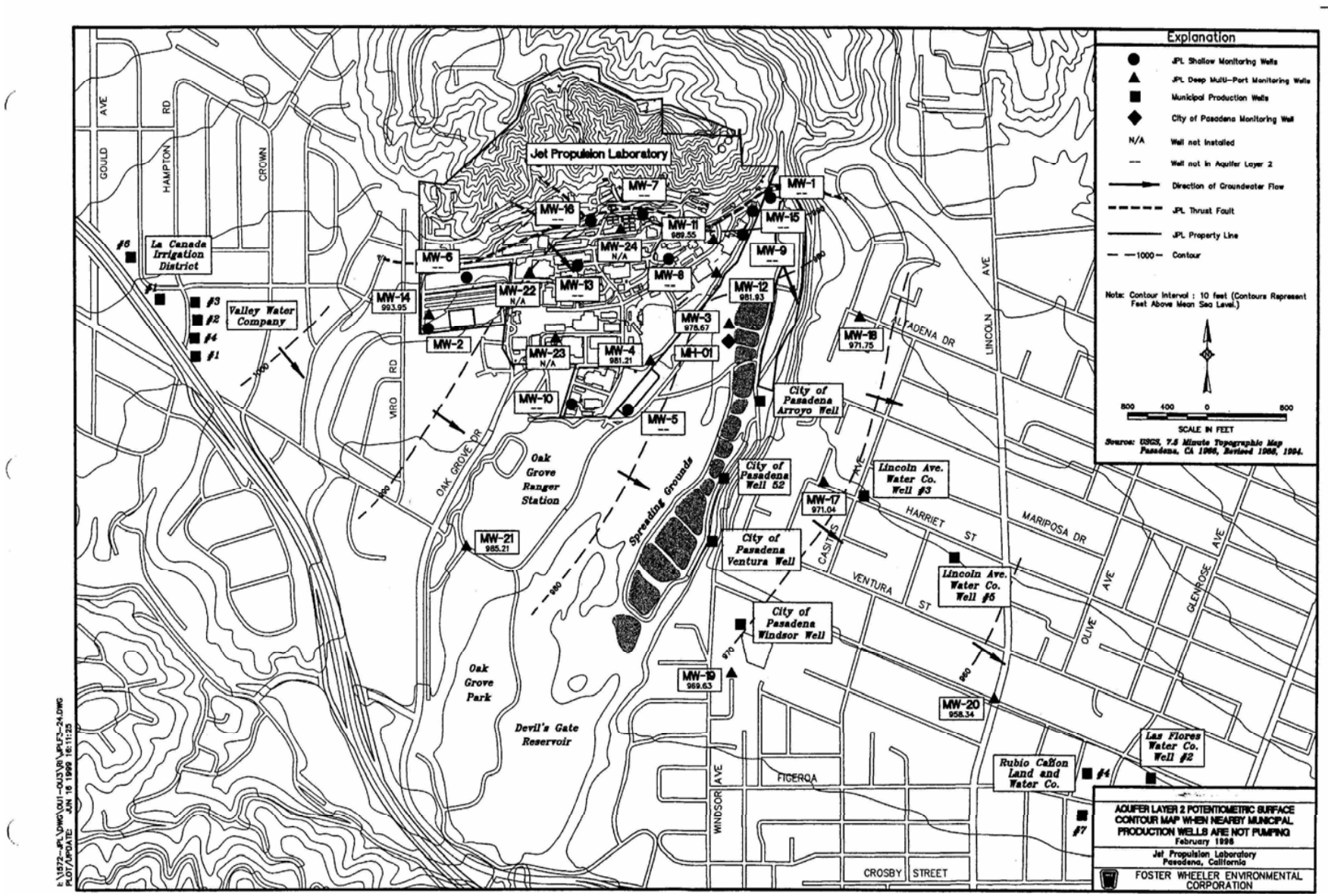

Figure 10. Aquifer Layer 2 Potentiometric Surface Contour Map When Nearby Municipal Production Wells Are Not Operating

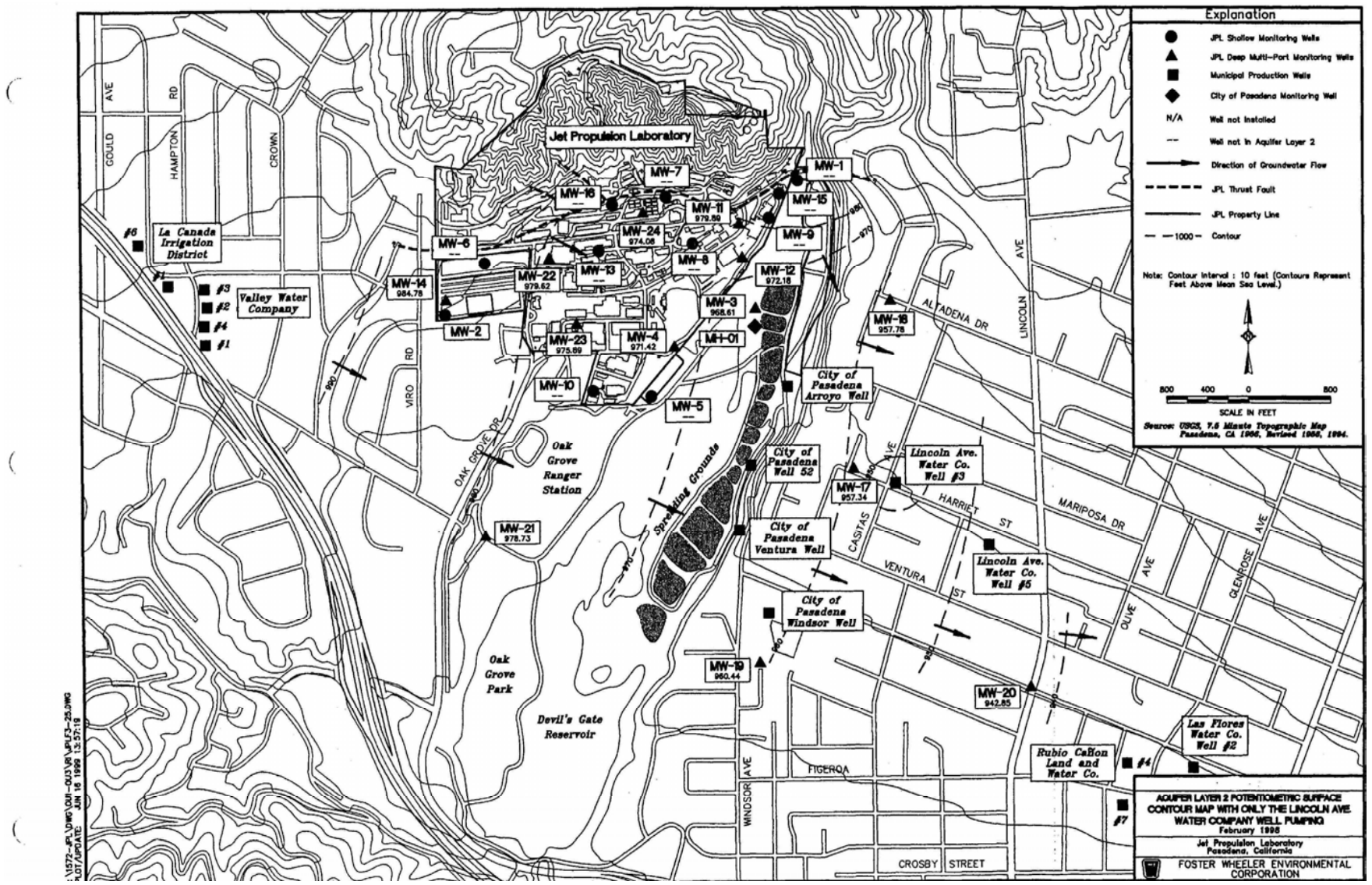

Figure 11. Aquifer Layer 2 Potentiometric Surface Contour Map With LAWC #3 Well Pumping

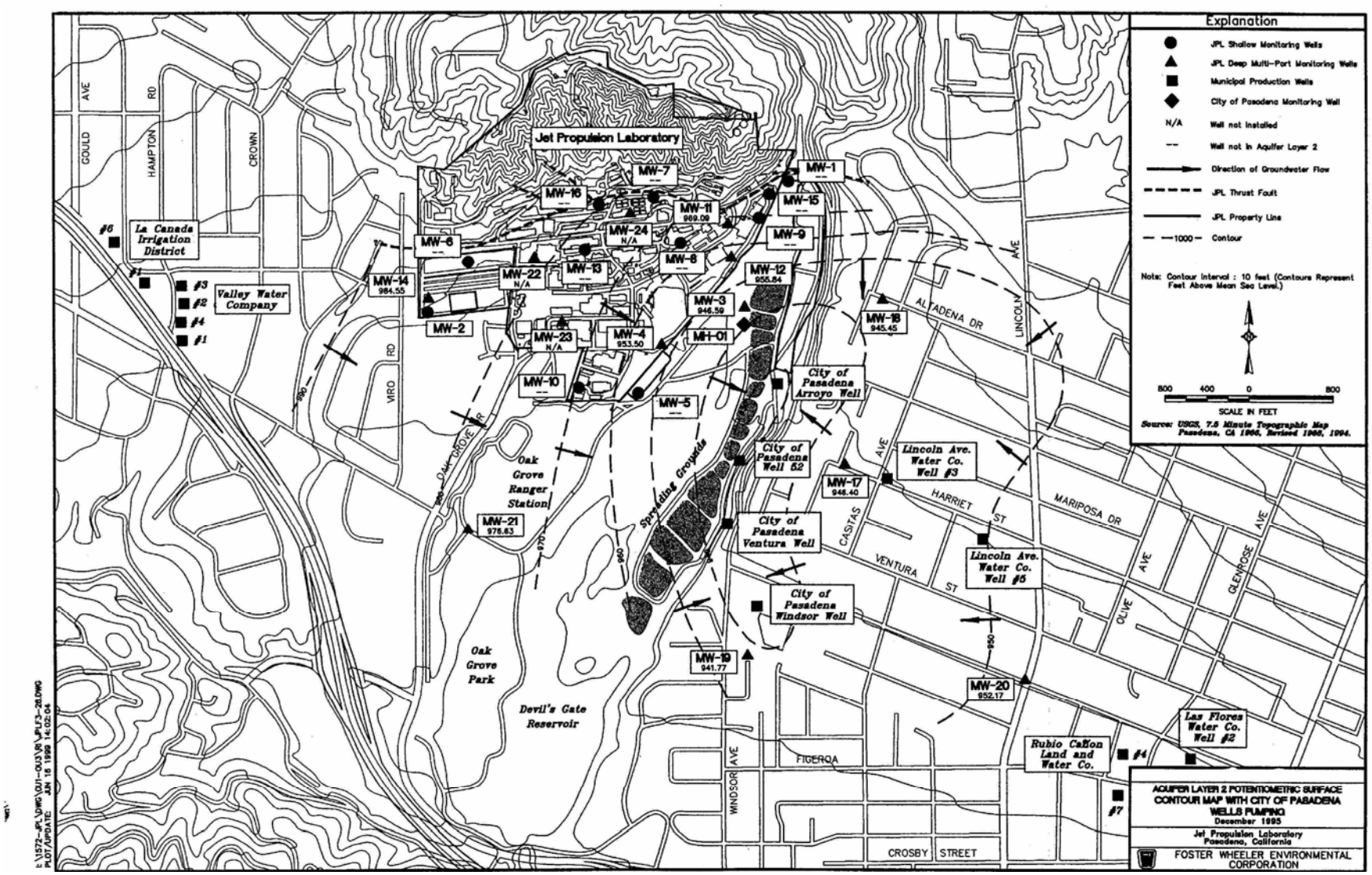

Figure 12. Aquifer Layer 2 Potentiometric Surface Contour Map With City of Pasadena Wells Pumping

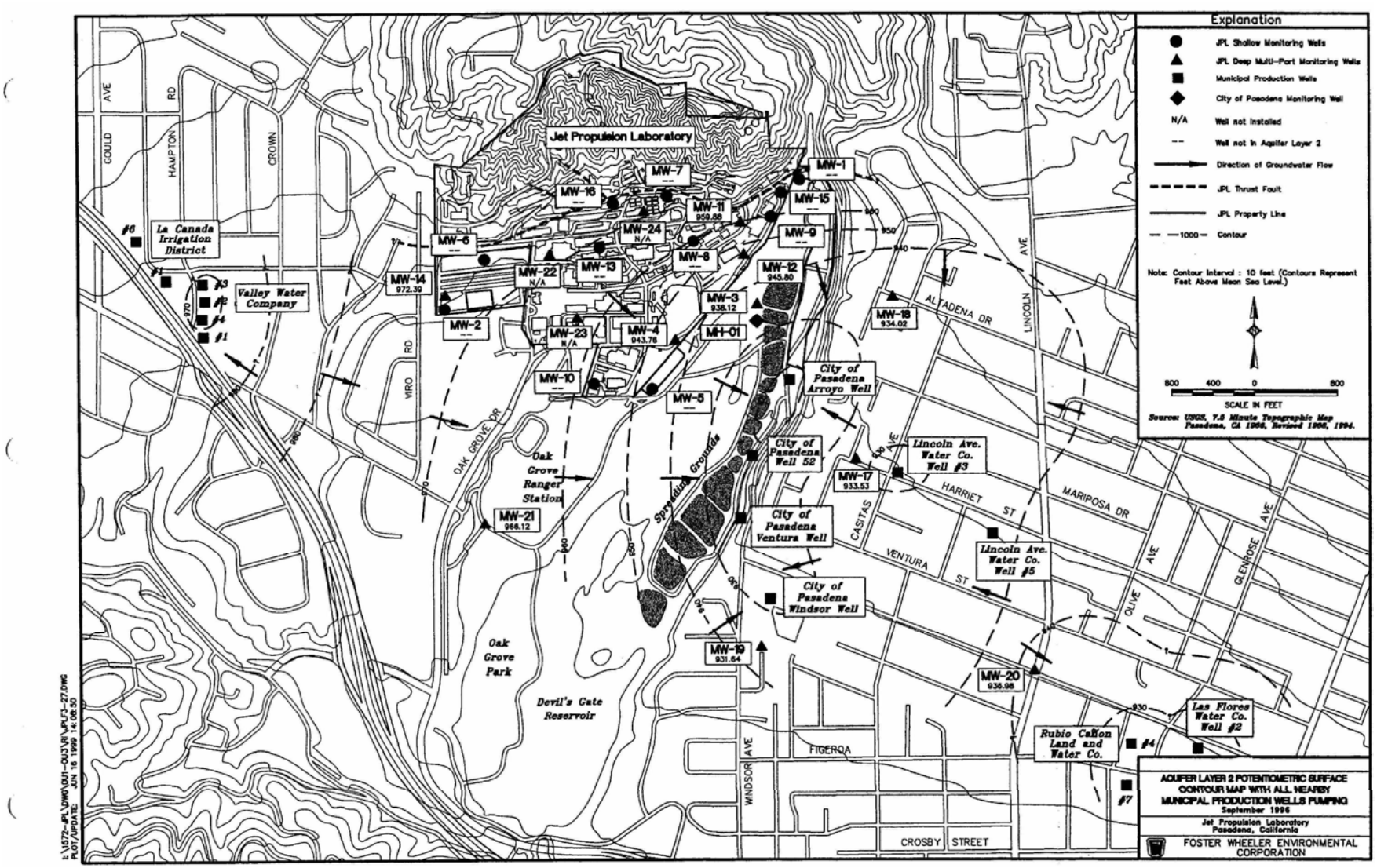

Figure 13. Aquifer Layer 2 Potentiometric Surface Contour Map With All Nearby Municipal Production Wells Pumping

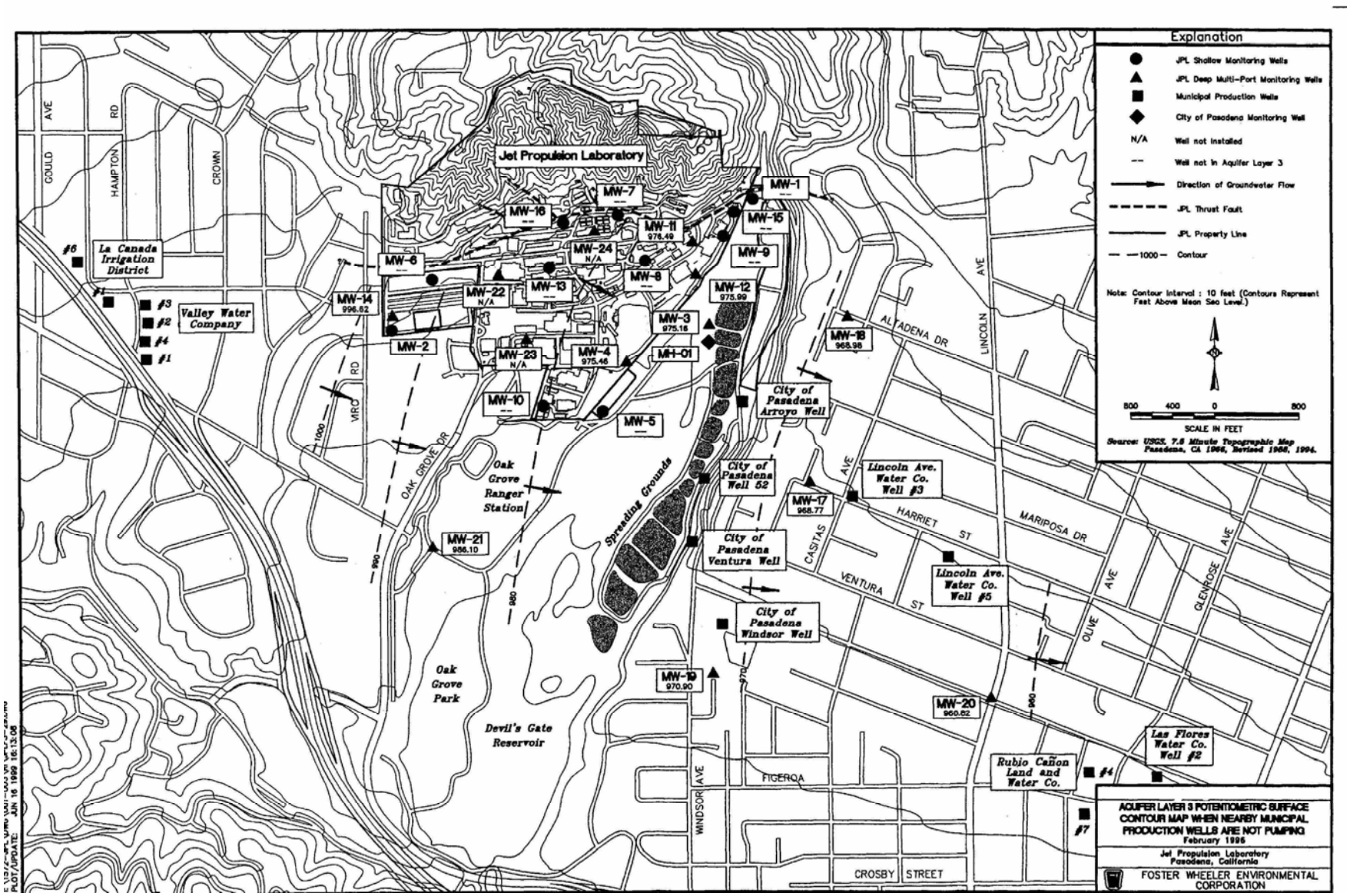

Figure 14. Aquifer Layer 3 Potentiometric Surface Contour Map When Nearby Municipal Production Wells Are Not Operating

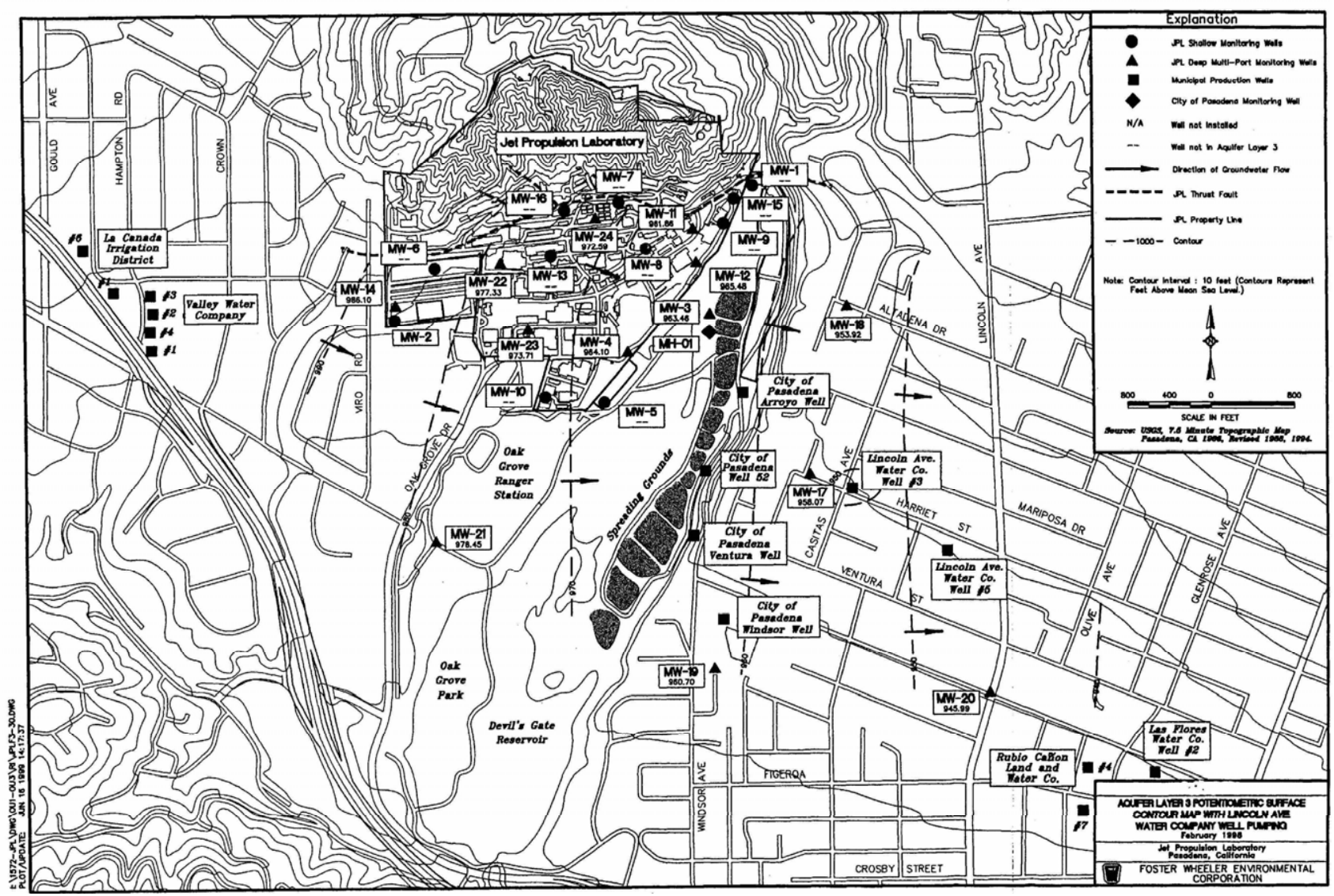

Figure 15. Aquifer Layer 3 Potentiometric Surface Contour Map With LAWC #3 Well Pumping

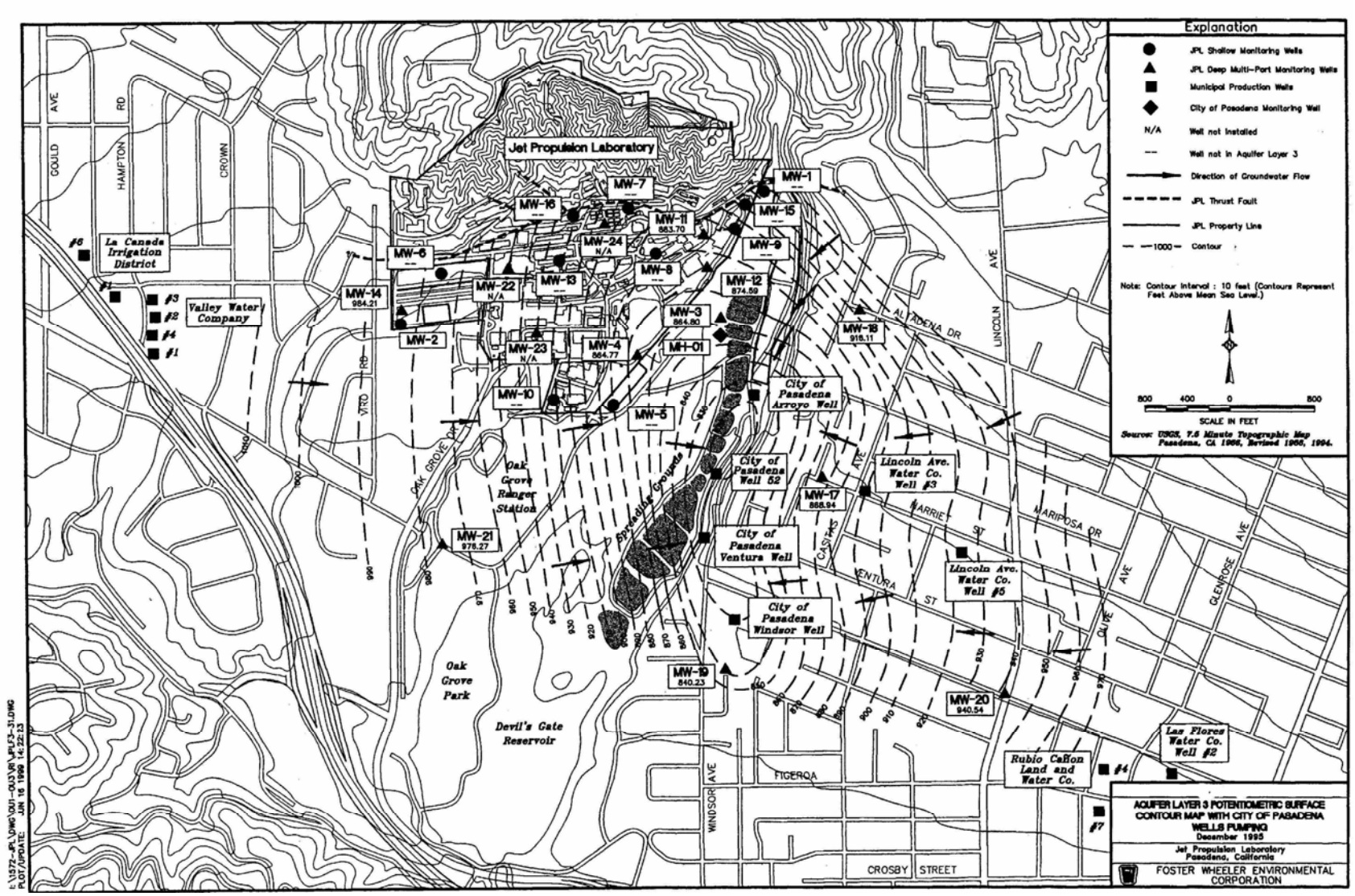

Figure 16. Aquifer Layer 3 Potentiometric Surface Contour Map With City of Pasadena Wells Pumping

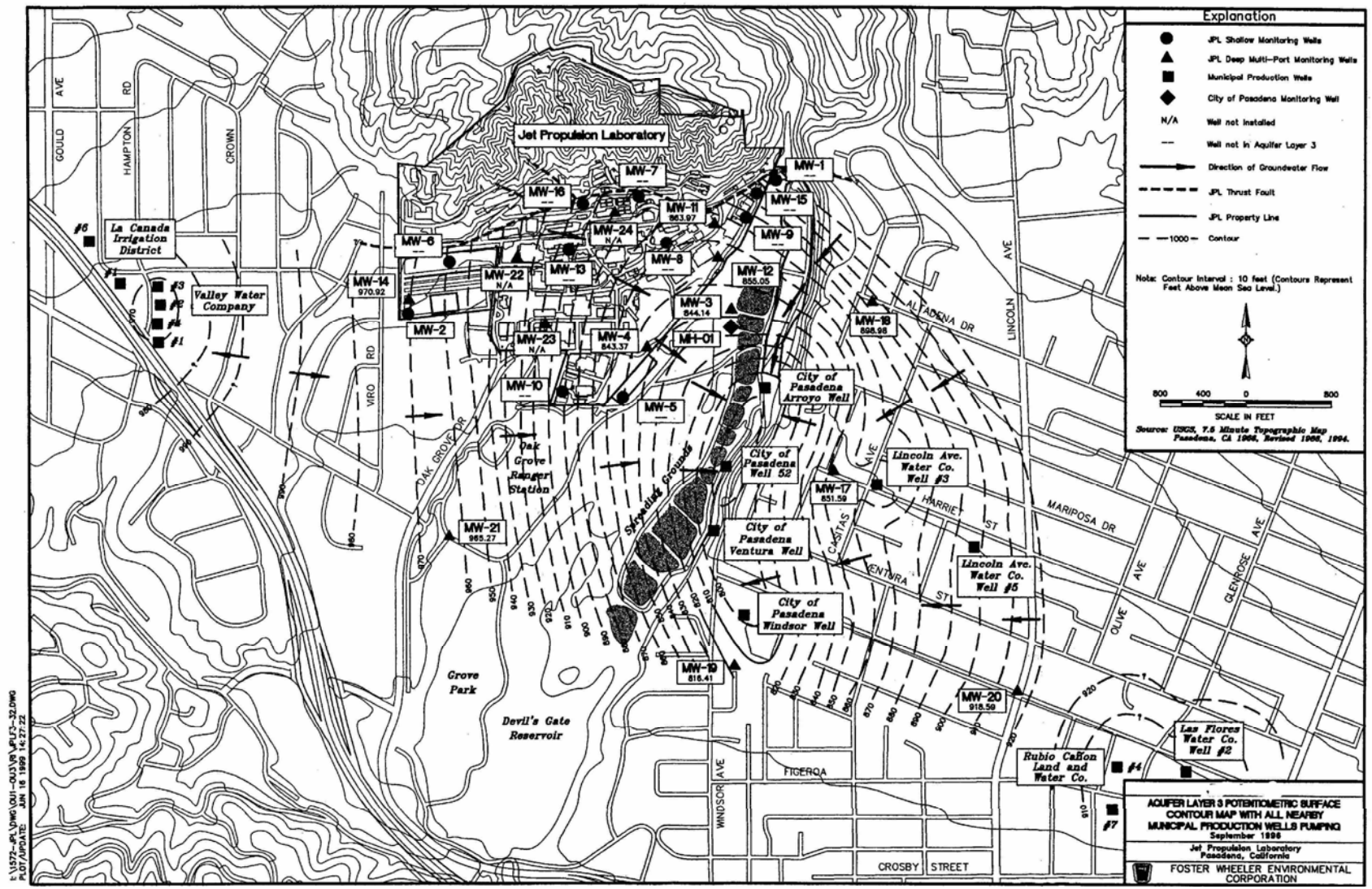

Figure 17. Aquifer Layer 3 Potentiometric Surface Contour Map With All Nearby Municipal Production Wells Pumping

Attachment 1
Nitrate Analytical Data

Well	Date	Result	Units
Arroyo	8/22/86	25.4	mg/L
	9/28/89	1.8	mg/L
	9/28/90	14	mg/L
	6/23/93	13.05	mg/L
	12/6/95	9.6	mg/L
	4/16/96	6.54	mg/L
	2/21/97	5.96	mg/L
Well 52	9/28/90	31	mg/L
	6/23/93	27.64	mg/L
	12/6/95	18.3	mg/L
	4/16/96	17.31	mg/L
	2/21/97	30.15	mg/L
	1/7/98	41.7	mg/L
	6/3/98	17.3	mg/L
	7/1/98	16.83	mg/L
	8/5/98	15.99	mg/L
	2/3/99	22.71	mg/L
	3/4/99	17.56	mg/L
	5/12/99	28.25	mg/L
	5/24/99	18.7	mg/L
	6/2/99	16.87	mg/L
	6/10/99	13.64	mg/L
	7/7/99	14.15	mg/L
	7/14/99	14.53	mg/L
	8/4/99	15.58	mg/L
	8/9/99	15.76	mg/L
	8/12/99	13.58	mg/L
	10/11/99	6.45	mg/L
	2/2/00	19.88	mg/L
	2/10/00	15.3	mg/L
	3/2/00	16	mg/L
	3/29/00	25	mg/L
	5/1/00	15.36	mg/L
	6/8/00	22.48	mg/L
	7/12/00	14.2	mg/L
	8/2/00	14	mg/L
	9/12/00	17	mg/L
	10/4/00	19.12	mg/L
	11/15/00	14.78	mg/L
	12/13/00	16.31	mg/L
	1/23/01	32.91	mg/L
	3/14/01	25.33	mg/L
	3/21/01	20.33	mg/L
	3/29/01	21.79	mg/L
	4/4/01	14.53	mg/L
	5/22/01	23.1	mg/L
	5/30/01	16.37	mg/L
	6/5/01	17.77	mg/L
	7/3/01	18.24	mg/L
	7/18/01	54.99	mg/L
	8/15/01	16.72	mg/L
	9/19/01	15.58	mg/L
	10/3/01	18.14	mg/L
	11/7/01	15.92	mg/L

Well	Date	Result	Units
	12/5/01	15.85	mg/L
	1/9/02	16	mg/L
	4/24/02	38.06	mg/L
	5/15/02	38.36	mg/L
	6/5/02	39.8	mg/L
	7/17/02	44.1	mg/L
	8/14/02	47	mg/L
	9/18/02	50.8	mg/L
	10/9/02	51.7	mg/L
Ventura	7/23/87	27	mg/L
	9/28/90	59	mg/L
	6/23/93	57.71	mg/L
	5/22/96	42.42	mg/L
	1/8/98	32.8	mg/L
	5/6/98	36.79	mg/L
	6/3/98	37.62	mg/L
	7/1/98	38.67	mg/L
	8/5/98	36.39	mg/L
	1/6/99	31.33	mg/L
	2/3/99	31.33	mg/L
	3/4/99	38.18	mg/L
	5/12/99	37.78	mg/L
	5/24/99	34.7	mg/L
	6/2/99	30.35	mg/L
	6/10/99	30.95	mg/L
	7/7/99	32.99	mg/L
	7/14/99	35.45	mg/L
	8/4/99	36.36	mg/L
	8/9/99	36.42	mg/L
	8/12/99	35.46	mg/L
	10/11/99	30.87	mg/L
	2/2/00	19.88	mg/L
	2/10/00	36.4	mg/L
	3/2/00	35	mg/L
	5/1/00	34.57	mg/L
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	5/22/01	46.36	mg/L
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	6/5/01	43.37	mg/L
	7/3/01	44.92	mg/L
	7/18/01	54.99	mg/L
	8/15/01	46.93	mg/L
	9/19/01	37.51	mg/L
	10/3/01	43.63	mg/L
	11/7/01	38.77	mg/L
	12/5/01	36.55	mg/L
	1/9/02	35.58	mg/L
	4/24/02	56.8	mg/L

Well	Date	Result	Units
	5/15/02	53.52	mg/L
	6/5/02	51.7	mg/L
	7/17/02	54	mg/L
	8/14/02	56.5	mg/L
	9/18/02	59.6	mg/L
	10/9/02	61.7	mg/L
Windsor	8/18/88	21	mg/L
	6/23/93	32.22	mg/L
	12/6/95	23.2	mg/L
	4/16/96	22.08	mg/L
	2/21/97	23.89	mg/L
	1/8/98	20.8	mg/L
	4/13/98	20.5	mg/L
	5/6/98	22.09	mg/L
	6/3/98	23.33	mg/L
	7/1/98	23.97	mg/L
	8/5/98	23.3	mg/L
	1/6/99	22.63	mg/L
	2/3/99	21.65	mg/L
	3/4/99	23.94	mg/L
	5/12/99	28.06	mg/L
	5/24/99	24.9	mg/L
	6/2/99	22.35	mg/L
	6/10/99	20.51	mg/L
	7/7/99	20.85	mg/L
	7/14/99	22.4	mg/L
	8/4/99	23.58	mg/L
	8/9/99	23.11	mg/L
	8/12/99	21.19	mg/L
	10/11/99	19.1	mg/L
	2/2/00	19.88	mg/L
	2/10/00	23.3	mg/L
	3/2/00	24	mg/L
	3/2/00	23	mg/L
	5/1/00	22.51	mg/L
	6/8/00	21.13	mg/L
	7/12/00	21.25	mg/L
	8/2/00	22	mg/L
	9/12/00	26	mg/L
	10/4/00	29.65	mg/L
	11/8/00	22.49	mg/L
	12/13/00	23.89	mg/L
	1/23/01	23.49	mg/L
	3/14/01	25.73	mg/L
	3/21/01	26.17	mg/L
	3/29/01	28.83	mg/L
	4/4/01	19.62	mg/L
	4/12/01	21.17	mg/L
	4/18/01	23.96	mg/L
	4/25/01	19.92	mg/L
	5/2/01	21.79	mg/L
	5/9/01	24.44	mg/L
	5/16/01	24.35	mg/L
	5/22/01	26.64	mg/L
	5/30/01	23.51	mg/L

Well	Date	Result	Units
	6/5/01	26.76	mg/L
	7/3/01	28.29	mg/L
	8/15/01	27.18	mg/L
	9/19/01	23.42	mg/L
	10/3/01	26.66	mg/L
	11/7/01	23.25	mg/L
	12/5/01	21.86	mg/L
	1/9/02	21.38	mg/L
	4/24/02	26.34	mg/L
	5/15/02	25.36	mg/L
	6/5/02	31.5	mg/L
	7/17/02	48.9	mg/L
	8/14/02	48.6	mg/L
	9/18/02	55.6	mg/L
	10/9/02	50	mg/L
LAWC 3	4/16/93	10.1	mg/L
	4/4/94	5.9	mg/L
	6/12/95	8.6	mg/L
	6/17/96	6.3	mg/L
	6/2/97	6.16	mg/L
	6/1/98	5.8	mg/L
	6/1/99	4	mg/L
	5/8/00	4.52	mg/L
	5/23/01	4.2	mg/L
	5/5/02	18	mg/L
	8/5/02	4.3	mg/L
	4/18/05	11	mg/L
	5/3/05	12.4	mg/L
LAWC 5	4/16/93	12.3	mg/L
	4/4/94	10.5	mg/L
	6/12/95	15.5	mg/L
	6/17/96	17.2	mg/L
	6/2/97	19.3	mg/L
	6/1/98	14.1	mg/L
	6/1/99	14.5	mg/L
	5/8/00	18.2	mg/L
	5/23/01	12	mg/L
	5/5/02	14	mg/L
	8/5/02	14	mg/L
	4/18/05	13	mg/L
	5/3/05	2.9	mg/L
Las Flores	2/26/90	33.88	mg/L
	9/19/94	43.9	mg/L
	12/19/94	42.1	mg/L
	12/11/95	40.2	mg/L
	12/9/96	35.1	mg/L
	11/3/97	41.5	mg/L
	12/8/97	39.1	mg/L
	5/11/98	46.3	mg/L
	5/13/98	41	mg/L
	7/13/98	43.6	mg/L
	12/14/98	39.8	mg/L
	1/25/99	41.4	mg/L
	3/22/99	42.4	mg/L
	5/10/99	43.4	mg/L

Well	Date	Result	Units
	7/12/99	47.1	mg/L
	7/15/99	50.4	mg/L
	7/26/99	45.2	mg/L
	8/3/99	49	mg/L
	8/9/99	45.9	mg/L
	8/16/99	48	mg/L
	8/23/99	47.6	mg/L
	8/30/99	46.8	mg/L
	9/7/99	41.8	mg/L
	9/13/99	49.5	mg/L
	9/20/99	49.1	mg/L
	9/27/99	48.1	mg/L
	10/4/99	48.1	mg/L
	10/11/99	48.8	mg/L
	10/18/99	45.7	mg/L
	10/25/99	42.3	mg/L
	11/1/99	45.1	mg/L
	11/8/99	38.8	mg/L
	11/15/99	44.4	mg/L
	11/22/99	40.3	mg/L
	11/29/99	43.6	mg/L
	12/6/99	43.8	mg/L
	12/13/99	52	mg/L
	12/13/99	48.6	mg/L
	12/20/99	43.4	mg/L
	1/3/00	43.5	mg/L
	1/11/00	38.5	mg/L
	1/17/00	44.3	mg/L
	1/24/00	44.2	mg/L
	1/31/00	44.4	mg/L
	2/7/00	42.2	mg/L
	2/14/00	44.6	mg/L
	2/22/00	45.8	mg/L
	2/28/00	40	mg/L
	3/6/00	47	mg/L
	3/12/00	44	mg/L
	3/20/00	44	mg/L
	3/27/00	44	mg/L
	4/3/00	43	mg/L
	4/10/00	44	mg/L
	4/17/00	44	mg/L
	4/24/00	45	mg/L
	5/1/00	44.6	mg/L
	5/8/00	47.6	mg/L
	5/15/00	47.9	mg/L
	5/22/00	46.1	mg/L
	5/30/00	48.1	mg/L
	6/5/00	44.5	mg/L
	6/12/00	48	mg/L
	6/19/00	47.6	mg/L
	6/26/00	43.5	mg/L
	7/3/00	44.5	mg/L
	7/10/00	44.2	mg/L
	8/16/00	60.3	mg/L
	8/21/00	53.7	mg/L

Well	Date	Result	Units
	8/28/00	58	mg/L
	9/5/00	52	mg/L
	9/11/00	50	mg/L
	9/18/00	49	mg/L
	9/25/00	47	mg/L
	10/2/00	47	mg/L
	10/9/00	45	mg/L
	10/16/00	38	mg/L
	10/23/00	44.3	mg/L
	10/30/00	46	mg/L
	11/6/00	40.3	mg/L
	11/13/00	45.9	mg/L
	11/27/00	46.3	mg/L
	12/4/00	40.6	mg/L
	12/11/00	45.4	mg/L
	12/18/00	44.6	mg/L
	12/26/00	39.8	mg/L
	1/2/01	45	mg/L
	1/8/01	39	mg/L
	1/15/01	44	mg/L
	1/22/01	45	mg/L
	1/29/01	45	mg/L
	2/5/01	44	mg/L
	2/12/01	39	mg/L
	2/20/01	41	mg/L
	2/26/01	44	mg/L
	3/5/01	38	mg/L
	3/12/01	42	mg/L
	3/19/01	37	mg/L
	3/26/01	46	mg/L
	4/2/01	40	mg/L
	4/9/01	44	mg/L
	4/16/01	45	mg/L
	4/23/01	45	mg/L
	4/30/01	45	mg/L
	5/7/01	46	mg/L
	5/14/01	48	mg/L
	5/21/01	42	mg/L
	5/29/01	47	mg/L
	6/4/01	48	mg/L
	6/11/01	52	mg/L
	6/18/01	47	mg/L
	6/25/01	51	mg/L
	7/2/01	58	mg/L
	7/9/01	46	mg/L
	7/16/01	46	mg/L
	7/23/01	48	mg/L
	7/30/01	46	mg/L
	8/6/01	47	mg/L
	8/13/01	49	mg/L
	8/20/01	50	mg/L
	8/27/01	56	mg/L
	9/4/01	58	mg/L
	9/10/01	50	mg/L
	9/17/01	50	mg/L

Well	Date	Result	Units
	9/24/01	50	mg/L
	10/1/01	55	mg/L
	10/8/01	49	mg/L
	10/15/01	47	mg/L
	10/22/01	47	mg/L
	10/29/01	47	mg/L
	11/5/01	48	mg/L
	11/12/01	47	mg/L
	11/19/01	47	mg/L
	11/26/01	45	mg/L
	12/3/01	46	mg/L
	12/10/01	46	mg/L
	12/17/01	47	mg/L
	12/26/01	48	mg/L
	1/2/02	49	mg/L
	1/7/02	47	mg/L
	1/14/02	46	mg/L
	1/21/02	46	mg/L
	1/28/02	47	mg/L
	2/4/02	47	mg/L
	2/11/02	45	mg/L
	2/19/02	45	mg/L
	2/25/02	46	mg/L
	3/4/02	46	mg/L
	3/11/02	46	mg/L
	3/18/02	46	mg/L
	3/25/02	45	mg/L
	4/1/02	45	mg/L
	4/8/02	41	mg/L
	4/15/02	48	mg/L
	4/22/02	48	mg/L
	4/29/02	46	mg/L
	5/6/02	44	mg/L
	5/13/02	49	mg/L
	5/20/02	49	mg/L
	5/28/02	52	mg/L
	6/3/02	50	mg/L
	6/10/02	43	mg/L
	6/17/02	46	mg/L
	6/24/02	50	mg/L
	7/1/02	50	mg/L
	7/8/02	51	mg/L
	7/15/02	41	mg/L
	7/22/02	49	mg/L
	7/29/02	51	mg/L
	8/5/02	49	mg/L
	8/12/02	48	mg/L
	8/26/02	50	mg/L
	9/3/02	49	mg/L
	9/9/02	47	mg/L
	9/16/02	48	mg/L
	9/23/02	50	mg/L
	4/28/03	46	mg/L
Rubio 4	6/20/89	42.8	mg/L
	5/4/92	21.3	mg/L

Well	Date	Result	Units
	5/18/92	26	mg/L
	5/20/92	34.8	mg/L
	5/27/92	41	mg/L
	6/8/92	51.8	mg/L
	6/15/92	53.4	mg/L
	6/18/92	53.4	mg/L
	6/18/92	36.2	mg/L
	6/22/92	48.9	mg/L
	6/29/92	54.1	mg/L
	3/8/93	11.5	mg/L
	3/15/93	11	mg/L
	1/10/94	26.4	mg/L
	4/4/94	39.8	mg/L
	7/5/94	42.6	mg/L
	10/3/94	33.4	mg/L
	12/27/94	26.4	mg/L
	1/3/95	18.7	mg/L
	4/10/95	24.7	mg/L
	6/13/95	39.8	mg/L
	7/5/95	46.5	mg/L
	10/2/95	41.5	mg/L
	1/2/96	41.7	mg/L
	7/1/96	41.3	mg/L
	10/7/96	36.5	mg/L
	1/6/97	16.6	mg/L
	4/7/97	24	mg/L
	4/21/97	30.6	mg/L
	7/7/97	37.6	mg/L
	10/6/97	34.3	mg/L
	1/5/98	21.3	mg/L
	4/6/98	16.2	mg/L
	7/6/98	36.3	mg/L
	10/5/98	38.5	mg/L
	1/4/99	24.7	mg/L
	4/5/99	15.9	mg/L
	7/6/99	36.7	mg/L
	8/2/99	38.4	mg/L
	10/4/99	39.5	mg/L
	1/3/00	18.9	mg/L
	4/3/00	19	mg/L
	4/24/00	16	mg/L
	7/3/00	22	mg/L
	10/2/00	20.9	mg/L
	12/4/00	21.4	mg/L
	1/2/01	20	mg/L
	1/29/01	14	mg/L
	4/2/01	16	mg/L
	6/18/01	33	mg/L
	7/2/01	36	mg/L
	10/8/01	22	mg/L
	1/7/02	27	mg/L
	4/2/02	14	mg/L
	7/1/02	33	mg/L
	10/7/02	18	mg/L
	1/7/03	14	mg/L

Well	Date	Result	Units
	1/13/03	14	mg/L
Rubio 7	5/4/92	13.4	mg/L
	5/18/92	17.4	mg/L
	5/20/92	16.5	mg/L
	5/26/92	22.2	mg/L
	6/1/92	23.6	mg/L
	6/8/92	22.6	mg/L
	6/15/92	22.5	mg/L
	6/18/92	22.5	mg/L
	6/22/92	21.4	mg/L
	3/8/93	7.4	mg/L
	3/15/93	9.1	mg/L
	6/7/93	20.3	mg/L
	1/10/94	10.1	mg/L
	4/4/94	18.9	mg/L
	7/5/94	23.4	mg/L
	10/3/94	21.8	mg/L
	12/27/94	10.2	mg/L
	1/3/95	10.1	mg/L
	4/10/95	17.4	mg/L
	6/13/95	22.6	mg/L
	7/5/95	23.3	mg/L
	10/2/95	26	mg/L
	1/2/96	31.3	mg/L
	7/1/96	26	mg/L
	10/7/96	20.8	mg/L
	1/6/97	25.6	mg/L
	4/7/97	24.3	mg/L
	4/21/97	26.1	mg/L
	7/7/97	24.7	mg/L
	10/6/97	26.4	mg/L
	1/5/98	26.8	mg/L
	4/6/98	13.3	mg/L
	7/6/98	24.4	mg/L
	10/5/98	24.3	mg/L
	1/4/99	22.5	mg/L
	4/5/99	19.7	mg/L
	7/6/99	22.2	mg/L
	10/4/99	24.1	mg/L
	1/3/00	22.2	mg/L
	4/3/00	19	mg/L
	4/24/00	18	mg/L
	7/3/00	24.7	mg/L
	10/2/00	23.5	mg/L
	12/4/00	21.9	mg/L
	1/2/01	21	mg/L
	1/29/01	21	mg/L
	4/2/01	17	mg/L
	6/18/01	23	mg/L
	7/2/01	26	mg/L
	10/8/01	26	mg/L
	1/7/02	24	mg/L
	4/2/02	20	mg/L
	7/1/02	23	mg/L
	10/7/02	13	mg/L

Well	Date	Result	Units
	1/7/03	13	mg/L
	1/13/03	13	mg/L
			mg/L
Valley #1	6/20/1989	32	mg/L
	3/6/1990	58.5	mg/L
	12/11/1991	60.4	mg/L
	2/2/1993	61.1	mg/L
	4/12/1993	57	mg/L
	6/1/1993	57	mg/L
	5/16/1994	26	mg/L
	6/6/1994	24	mg/L
	6/17/1994	24.64	mg/L
	12/13/1994	42.24	mg/L
	3/9/1995	7.48	mg/L
	6/14/1995	32.56	mg/L
	7/10/1995	32.56	mg/L
	8/1/1995	33.44	mg/L
	9/5/1995	44	mg/L
	10/2/1995	44	mg/L
	5/1/1996	7.48	mg/L
	6/5/1996	27.28	mg/L
	7/9/1996	30.8	mg/L
	8/6/1996	32.56	mg/L
	5/12/1997	33.44	mg/L
	6/10/1997	29.92	mg/L
	7/7/1997	34.76	mg/L
	8/11/1997	40.04	mg/L
	5/4/1998	19.8	mg/L
	6/1/1998	29.04	mg/L
	6/15/1998	26.84	mg/L
	8/3/1998	36.08	mg/L
	9/1/1998	38.72	mg/L
	10/5/1998	42.68	mg/L
	5/3/1999	8.8	mg/L
	7/7/1999	73.92	mg/L
	8/2/1999	41.8	mg/L
	9/7/1999	47.96	mg/L
	10/4/1999	51.48	mg/L
	5/1/2000	19.008	mg/L
	6/5/2000	31.196	mg/L
	7/5/2000	40.216	mg/L
	8/1/2000	43.296	mg/L
	10/2/2000	49	mg/L
	5/1/2001	11.88	mg/L
	6/4/2001	26.84	mg/L
	8/6/2001	42.68	mg/L
	9/4/2001	48.4	mg/L
	10/1/2001	48.4	mg/L
	4/23/2002	5.28	mg/L
	5/1/2002	4.84	mg/L
	6/3/2002	22.44	mg/L
	7/1/2002	27.72	mg/L
	8/5/2002	33.44	mg/L
	9/3/2002	35.2	mg/L
	10/2/2002	36.08	mg/L

Well	Date	Result	Units
Valley #2	12/30/1987	83.6	mg/L
	12/9/1993	70.4	mg/L
	7/5/1994	8.4	mg/L
	8/8/1994	57.2	mg/L
	9/6/1994	48.4	mg/L
	10/18/1994	52.8	mg/L
	11/7/1994	48.4	mg/L
	12/13/1994	61.6	mg/L
	3/9/1995	0	mg/L
	4/3/1995	0	mg/L
	4/20/1995	6.16	mg/L
	5/1/1995	16.72	mg/L
	6/5/1995	36.52	mg/L
	6/13/1995	39.16	mg/L
	7/5/1995	44	mg/L
	8/1/1995	48.4	mg/L
	9/5/1995	57.2	mg/L
	10/2/1995	52.8	mg/L
	11/6/1995	52.8	mg/L
	5/6/1996	2.2	mg/L
	6/3/1996	36.96	mg/L
	6/4/1996	36.96	mg/L
	7/1/1996	48.4	mg/L
	8/5/1996	52.8	mg/L
	9/3/1996	48.4	mg/L
	10/1/1996	48.4	mg/L
	5/5/1997	43.56	mg/L
	7/1/1997	52.8	mg/L
	8/4/1997	57.2	mg/L
	9/2/1997	52.8	mg/L
	1/12/1998	57.2	mg/L
	5/6/1998	0	mg/L
	6/1/1998	36.96	mg/L
	6/17/1998	57.2	mg/L
	7/6/1998	70.4	mg/L
	8/3/1998	70.4	mg/L
	9/1/1998	74.8	mg/L
	5/3/1999	0	mg/L
	6/1/1999	48.84	mg/L
	7/7/1999	69.96	mg/L
	8/2/1999	73.48	mg/L
	9/7/1999	77.44	mg/L
	5/1/2000	32.78	mg/L
	6/5/2000	70.84	mg/L
	7/5/2000	76.12	mg/L
	8/1/2000	70.4	mg/L
	9/7/2000	65	mg/L
	5/1/2001	2.64	mg/L
	6/4/2001	70.4	mg/L
	8/6/2001	79.2	mg/L
	10/1/2001	70.4	mg/L
	4/23/2002	0	mg/L
	5/6/2002	2.024	mg/L
	6/3/2002	0	mg/L
	7/1/2002	0	mg/L

Well	Date	Result	Units
	8/5/2002	0	mg/L
Valley #3	6/12/1995	61.6	mg/L
	7/31/1995	61.6	mg/L
	9/5/1995	57.2	mg/L
	12/5/1995	61.6	mg/L
	5/6/1996	39.16	mg/L
	6/5/1996	48.4	mg/L
	7/9/1996	66	mg/L
	8/6/1996	52.8	mg/L
	9/3/1996	48.4	mg/L
	10/1/1996	48.4	mg/L
	5/5/1997	3.52	mg/L
	7/1/1997	41.36	mg/L
	8/4/1997	52.8	mg/L
	9/2/1997	48.4	mg/L
	1/12/1998	9.68	mg/L
	5/6/1998	41.8	mg/L
	6/1/1998	48.4	mg/L
	6/15/1998	40.48	mg/L
	7/6/1998	52.8	mg/L
	8/3/1998	57.2	mg/L
	9/1/1998	61.6	mg/L
	5/3/1999	23.32	mg/L
	6/1/1999	69.08	mg/L
	7/7/1999	50.6	mg/L
	8/2/1999	69.08	mg/L
	9/7/1999	69.08	mg/L
	5/1/2000	45.32	mg/L
	6/5/2000	47.96	mg/L
	7/5/2000	71.72	mg/L
	8/1/2000	69.08	mg/L
	5/1/2001	40.92	mg/L
	6/4/2001	61.6	mg/L
	8/6/2001	70.4	mg/L
	10/1/2001	70.4	mg/L
	4/23/2002	20.68	mg/L
	5/6/2002	44	mg/L
	6/3/2002	70.4	mg/L
	7/1/2002	70.4	mg/L
	8/5/2002	66	mg/L
Valley #4	6/20/1989	53	mg/L
	3/6/1990	52.5	mg/L
	9/17/1991	55.8	mg/L
	12/11/1991	53.8	mg/L
	7/6/1992	53	mg/L
	9/16/1992	51.3	mg/L
	11/9/1992	36	mg/L
	2/2/1993	54.8	mg/L
	6/1/1993	57	mg/L
	9/27/1993	57	mg/L
	12/13/1993	57.2	mg/L
	6/17/1994	4.4	mg/L
	8/1/1994	40.04	mg/L
	11/15/1994	48.4	mg/L
	12/13/1994	52.8	mg/L

Well	Date	Result	Units
	3/9/1995	0	mg/L
	6/14/1995	36.08	mg/L
	7/10/1995	33.88	mg/L
	9/5/1995	44	mg/L
	5/6/1996	2.64	mg/L
	6/3/1996	31.24	mg/L
	6/4/1996	30.8	mg/L
	7/1/1996	37.84	mg/L
	8/5/1996	42.24	mg/L
	9/16/1996	44	mg/L
	5/12/1997	61.6	mg/L
	6/10/1997	52.8	mg/L
	7/7/1997	52.8	mg/L
	5/4/1998	10.12	mg/L
	6/1/1998	33.44	mg/L
	6/15/1998	40.92	mg/L
	8/3/1998	52.8	mg/L
	9/1/1998	52.8	mg/L
	10/5/1998	57.2	mg/L
	5/3/1999	2.772	mg/L
	6/1/1999	35.376	mg/L
	8/2/1999	53.68	mg/L
	9/7/1999	55.88	mg/L
	10/6/1999	62.92	mg/L
	5/1/2000	18.568	mg/L
	6/5/2000	46.64	mg/L
	7/5/2000	53.68	mg/L
	8/1/2000	54.56	mg/L
	10/2/2000	56	mg/L
	5/1/2001	11	mg/L
	6/4/2001	44	mg/L
	8/6/2001	61.6	mg/L
	9/4/2001	57.2	mg/L
	10/1/2001	57.2	mg/L
	4/23/2002	3.652	mg/L
	5/1/2002	3.784	mg/L
	6/3/2002	21.12	mg/L
	7/1/2002	23.76	mg/L
	8/5/2002	25.52	mg/L
	9/3/2002	25.08	mg/L
	10/2/2002	25.96	mg/L